Environmental Noise Assessments

Riverside South Elementary School

Ottawa, Ontario

REPORT: GWE18-094 – Environmental Noise

Prepared For:

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EXECUTIVE SUMMARY

This document describes an environmental noise assessment performed for a proposed Riverside South Elementary School development in Ottawa, Ontario. The development comprises a new two-storey building as well as provisions for future expansion with and eastern wing as well as eight portable classroom units. The site is located southeast of the Ralph Hennessy Avenue & Mount Nebo Way intersection. The site is surrounded on all sides by future low-rise residential dwellings. The major source of transportation noise is Ralph Hennessy Avenue. The major sources of stationary noise are from rooftop mechanical equipment atop the proposed building. Figure 1 illustrates a complete site plan with surrounding context.

The assessment is based on: (i) theoretical noise prediction methods that conform to the Ministry of the Environment and Climate Change (MOECC) and City of Ottawa requirements; (ii) noise level criteria as specified by the City of Ottawa's Environmental Noise Control Guidelines (ENCG); (iii) future vehicular traffic volumes based on the City of Ottawa's Official Plan roadway classifications; and (iv) preliminary architectural drawings and mechanical information received from Pye & Richards Architects Incorporated.

The results of the roadway noise assessment indicate combined noise levels will range between 47 and 62 dBA during the daytime period (07:00-23:00) and between 40 and 55 dBA during the nighttime period (23:00-07:00). The highest noise levels (i.e. 62 dBA) occurs along the development's west façade, which is nearest and most exposed to Ralph Hennessy Avenue. Noise levels fall below the ENCG criteria for upgraded building components, however the development will require force-air heating with provision for air conditioning. Air conditioning will allow windows to remain closed while maintaining a comfortable indoor environment.

Stationary noise levels fall below ENCG criteria during all hours of the day. Since the noise levels fall below ENCG criteria, the proposed development is expected to be compatible with the existing and future noise sensitive land uses. A review of final equipment selection and locations by a qualified acoustical engineer will be required prior to installation of the equipment.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (GWE) was retained by Conseil des écoles catholiques du Centre-Est to undertake an environmental noise assessment of the proposed Riverside South Elementary School development in Ottawa, Ontario. This report summarizes the methodology, results and recommendations related to an environmental noise assessment. GWE's scope of work involved assessing exterior and interior noise levels generated by local roadway traffic, as well as consideration of stationary impacts from proposed mechanical equipment. The assessment was performed on the basis of theoretical noise calculation methods conforming to the City of Ottawa[1] and Ministry of the Environment and Climate Change (MOECC)[2] guidelines. Noise calculations were based on architectural drawings and mechanical information received from Pye & Richards Architects Incorporated, and future traffic volumes corresponding to the City of Ottawa's Official Plan (OP) roadway classifications.

2. TERMS OF REFERENCE

The focus of this environmental noise assessment is the proposed Riverside South Elementary School development, comprising a new two-storey building as well as provisions for future expansion with and eastern wing as well as eight portable classroom units. The site is located southeast of the Ralph Hennessy Avenue & Mount Nebo Way intersection. The site is surrounded on all sides by future low-rise residential dwellings. The major source of transportation noise is Ralph Hennessy Avenue. The major sources of stationary noise are from rooftop mechanical equipment atop the proposed building. Figure 1 illustrates a complete site plan with surrounding context.

3. OBJECTIVES

The main goals of this work are to: (i) calculate the future noise levels on the study building produced by local roadway traffic sources, (ii) calculate the future noise levels on surrounding noise-sensitive properties produced by stationary noise sources associated with the development, and (iii) ensure that interior and exterior noise levels do not exceed the allowable limits specified by the City of Ottawa's Environmental Noise Control Guidelines as outlined in Section 4 of this report.

[1] City of Ottawa Environmental Noise Control Guidelines, January 2016

[2] Ontario Ministry of the Environment and Climate Change – Environmental Noise Guidelines, Publication NPC-300, Queens Printer for Ontario, Toronto, 2013

4. METHODOLOGY

4.1 Background

Noise can be defined as any obtrusive sound. It is created at a source, transmitted through a medium, such as air, and intercepted by a receiver. Noise may be characterized in terms of the power of the source or the sound pressure at a specific distance. While the power of a source is characteristic of that particular source, the sound pressure depends on the location of the receiver and the path that the noise takes to reach the receiver. Measurement of noise is based on the decibel unit, dBA, which is a logarithmic ratio referenced to a standard noise level (2×10^{-5} Pascals). The 'A' suffix refers to a weighting scale, which better represents how the noise is perceived by the human ear. With this scale, a doubling of power results in a 3 dBA increase in measured noise levels and is just perceptible to most people. An increase of 10 dBA is often perceived to be twice as loud.

4.2 Transportation Noise

4.2.1 Criteria for Transportation Noise

For vehicle traffic, the equivalent sound energy level, L_{eq}, provides a measure of the time varying noise levels, which is well correlated with the annoyance of sound. It is defined as the continuous sound level, which has the same energy as a time varying noise level over a period of time. For roadways, the L_{eq} is commonly calculated on the basis of a 16-hour (L_{eq16}) daytime (07:00-23:00) / 8-hour (L_{eq8}) nighttime (23:00-07:00) split to assess its impact on residential buildings. The City of Ottawa's Environmental Noise Control Guidelines (ENCG) specifies that the recommended indoor noise limit (that is relevant to this study) is 45 dBA for schools, as listed in Table 1. To account for deficiencies in building construction, theses levels should be targeted toward 42 dBA.

TABLE 1: INDOOR SOUND LEVEL CRITERIA (ROAD & RAIL)[3]

Type of Space	Time Period	L_{eq} (dBA)	
		Road	Rail
General offices, reception areas, retail stores, etc.	07:00 – 23:00	50	45
Living/dining/den areas of residences, hospitals, **schools**, nursing/retirement homes, day-care centres, theatres, places of worship, libraries, individual or semi-private offices, conference rooms, etc.	07:00 – 23:00	45	40
Sleeping quarters of hotels/motels	23:00 – 07:00	45	40
Sleeping quarters of residences, hospitals, nursing/retirement homes, etc.	23:00 – 07:00	40	35

Predicted noise levels at the plane of window (POW) dictate the action required to achieve the recommended sound levels. An open window is considered to provide a 10 dBA reduction in noise, while a standard closed window is capable of providing a minimum 20 dBA noise reduction[4]. Therefore, where noise levels exceed 55 dBA daytime and 50 dBA nighttime, the ventilation for the building should consider the need for having windows and doors closed, which normally triggers the need for central air conditioning. Where noise levels exceed 65 dBA daytime and 60 dBA nighttime, building components will require higher levels of sound attenuation[5].

The sound level criterion for outdoor living areas is 55 dBA, which applies during the daytime (07:00 to 23:00). When noise levels exceed 55 dBA, mitigation must be provided to reduce noise levels where technically and administratively feasible to acceptable levels at or below the criterion. The only outdoor living area associated with the development would be the outdoor classroom.

4.2.1 Transportation Source Volumes

The ENCG dictates that noise calculations should consider future sound levels based on a roadway's classification at the mature state of development. Therefore, roadway traffic volumes are based on the roadway classifications outlined in the City of Ottawa's Official Plan (OP) and Transportation Master Plan[6] which provide additional details on future roadway expansions. Transitway volumes have been assumed

[3] Adapted from ENCG 2016 – Tables 2.2b and 2.2c
[4] Burberry, P.B.. (2014). Mitchell's Environment and Services. Routledge, Page 125
[5] MOECC, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.1.3
[6] City of Ottawa Transportation Master Plan, November 2013

based on nearby station information from OC Transpo. Average Annual Daily Traffic (AADT) volumes are then based on data in Table B1 of the ENCG for each roadway classification. Table 2 (below) summarizes the AADT values used for each roadway included in this assessment.

TABLE 2: ROADWAY TRAFFIC DATA

Segment	Roadway / Transit Class	Speed Limit (km/h)	Traffic Volumes
Ralph Hennessy Avenue	2-UCU	40	**8,000**

4.2.2 Theoretical Transportation Noise Predictions

Noise predictions were performed with the aid of the MOECC computerized noise assessment program, STAMSON 5.04, for road and rail analysis. Roadway traffic noise calculations were performed by treating each roadway segment as separate line sources of noise, and by using existing building locations as noise barriers. In addition to the traffic volumes summarized in Table 2, theoretical noise predictions were based on the following parameters:

- Truck traffic on all roadways was taken to comprise 5% heavy trucks and 7% medium trucks, as per ENCG requirements for noise level predictions.
- The day/night split was taken to be 92% / 8% respectively for all streets.
- Reflective and absorptive intermediate ground surfaces based on specific source-receiver path ground characteristics. Pavement, such as roads and parking lots, is considered as reflective ground, while vegetated space is considered as absorptive ground.
- Site is considered to be flat or gently sloping.

Noise receptors were strategically identified at six (6) locations around the proposed building, (see Figure 2). A complete set of input and output data from all STAMSON 5.04 calculations are available in Appendix A, and STAMSON input parameters are illustrated in Figure 3-5.

4.3 Indoor Noise Calculations

The difference between outdoor and indoor noise levels is the noise attenuation provided by the building envelope. According to common industry practice, complete walls and individual wall elements are rated according to the Sound Transmission Class (STC). The STC ratings of common commercial walls built in

conformance with the Ontario Building Code (2012) typically exceed STC 35, depending on exterior cladding, thickness and interior finish details. For example, 6" metal stud walls with gypsum board sheathing can achieve STC 45 or more. Standard good quality double-glazed non-operable windows can have STC ratings ranging from 25 to 40, depending on the window manufacturer, pane thickness and inter-pane spacing. As previously mentioned, the windows are the known weak point in a partition.

As per Section 4.2, when daytime noise levels (from road and rail sources) at the plane of the window exceed 65 dBA, calculations must be performed to evaluate the sound transmission quality of the building components to ensure acceptable indoor noise levels. The calculation procedure[7] considers:

- Window type and total area as a percentage of total room floor area
- Exterior wall type and total area as a percentage of the total room floor area
- Acoustic absorption characteristics of the room
- Outdoor noise source type and approach geometry
- Indoor sound level criteria, which varies according to the intended use of a space

Based on published research[8], exterior walls possess specific sound attenuation characteristics that are used as a basis for calculating the required STC ratings of windows in the same partition. Due to the limited information, available at the time of the study, which was prepared for site plan approval, detailed floor layouts and building elevations have not been finalized; therefore, detailed STC calculations could not be performed at this time. As a guideline, the anticipated STC requirements for windows have been estimated based on the overall noise reduction required for each intended use of space (STC = outdoor noise level – targeted indoor noise levels).

4.4 Stationary Noise

4.4.1 Assumptions

Preliminary mechanical information for the development has been provided by Pye & Richards Architects Incorporated. A review of final equipment selection and locations by a qualified acoustical engineer will be required prior to installation of the equipment. The following assumptions have been included in the analysis:

[7] Building Practice Note: Controlling Sound Transmission into Buildings by J.D. Quirt, National Research Council of Canada, September 1985
[8] CMHC, Road & Rail Noise: Effects on Housing

(i) The locations, quantity and tonnage of rooftop units have been assumed based on direction from Pye & Richards Architects Incorporated.

(ii) The sound data of rooftop units is based on manufacture's data.

(iii) During the daytime and evening period (07:00 – 23:00), the rooftop mechanical units (RTU) on the building are in full operation.

(iv) During the nighttime period (23:00 – 07:00), the rooftop mechanical units on the building are in operation 50% of the time.

(v) Screening effects of buildings and parapets have been considered in the modelling. Parapet heights are assumed to be a minimum of 0.7 m above the roof deck.

The equipment considered in the model consisted of:

(i) S1,2,9 – AAON Model RN 9 & 11 TON

(ii) S3 – AAON Model RN 8 & 10 TON

(iii) S4,7 – AAON Model RQ 4-6 RN 6 & 7 TON

(iv) S5 – AAON Model RN 25 & 30 TON

(v) S6,8 – AAON Model RN 13-20 TON

4.4.2 Stationary Noise Source Assessment and Criteria

For stationary sources, the L_{eq} is calculated on an hourly interval, while for roadways, the L_{eq} is calculated on the basis of a 16-hour daytime / 8-hour nighttime split. Noise criteria taken from the ENCG apply to points of reception (POR). A POR is defined under ENCG as "any location on a noise sensitive land use where noise from a stationary source is received", this can be an outdoor point of reception or at the plane of window. A POR can be located on an existing or zoned for future use premises of permanent or seasonal residences, hotels/motels, nursing/retirement homes, rental residences, hospitals, camp grounds, and noise sensitive buildings such as schools, and daycare facilities. According to the ENCG, the recommended maximum noise level for a suburban (Class 2) environment at a POR is either the lowest one-hour background noise level due to other sources, or the exclusionary limits outlined in Table 3, whichever is higher.

TABLE 3: EXCLUSIONARY LIMITS FOR CLASS 2 AREA

Time of Day	Outdoor Points of Reception	Plane of Window
07:00 – 19:00	50	50
19:00 – 23:00	45	50
23:00 – 07:00	N/A	45

4.4.3 Determination of Noise Source Power Levels

Table 4 summarizes the sound power levels of each source assumed in our analysis. Source locations are illustrated in Figure 6. Rooftop equipment sound power data is for the manufacture's test data.

TABLE 4: EQUIPMENT SOUND POWER LEVELS (dBA)

Source ID	Height above roof/grade (m)	Frequency (Hz)								
		63	125	250	500	1000	2000	4000	8000	Total
S1,2,9	1.5	66	71	74	79	78	75	72	69	84
S3	1.5	70	75	78	83	82	79	76	73	88
S4,7	1.5	63	68	71	76	75	72	69	66	81
S5	1.5	68	74	76	81	80	77	74	71	86
S6,8	1.5	73	78	81	86	85	82	79	76	91

4.4.4 Stationary Source Noise Predictions

The impact of the stationary noise sources on the nearby residential areas was determined by Predictor-Lima. A total of ten (10) receptor locations were chosen around the site to measure the noise impact at points of reception (POR) during the daytime and evening period (07:00 – 23:00), as well as the nighttime period (23:00 – 07:00). POR locations included outdoor points of reception (OPOR) and the plane of windows (POW) of the adjacent residential properties, as well as on-site locations. Sensor locations are described in Table 5 and illustrated in Figure 7. All units were represented as point sources in the Predictor model. Table 6 below contains Predictor-Lima calculation settings. These settings are typical and have been based on ISO 9613 standards and guidance from the MOECC.

Ground absorption over the study area was determined based on topographical features (such as water, concrete, grassland, etc.). An absorption value of 0 is representative of hard ground, while a value of 1 represents grass, and similar soft surface conditions. Existing and proposed buildings were added to the model to account for screening and reflection effects from building façades. A Predictor-Lima sample output is available in Appendix B, further modelling data are available upon request.

TABLE 5: RECEPTOR LOCATIONS

Receptor Number	Location	Height Above Grade (m)
R1	POW – Lot 51	4.5
R2	OPOR – Lot 51	1.5
R3	POW – Lot 272	4.5
R4	POW – Lot 212	4.5
R5	OPOR – Lot 212	1.5
R6	POW – Lot 174	4.5
R7	OPOR – Lot 174	1.5
R8	POW – Lot 149	4.5
R9	POW – Lot 146	4.5
R10	POW – Lot 143	4.5

TABLE 6: CALCULATION SETTINGS

Parameter	Setting
Meteorological correction method	Single value for C0
Value C0	2
Default ground attenuation factor	1
Ground attenuation factor for roadways and paved areas	0
Temperature (K)	283.15
Pressure (kPa)	101.33
Air humidity (%)	70

5. RESULTS AND DISCUSSION

5.1 Transportation Noise Levels

The results of the roadway traffic noise calculations are summarized in Table 7 below. A complete set of input and output data from all STAMSON 5.04 calculations are available in Appendix A.

TABLE 7: EXTERIOR NOISE LEVELS DUE TO TRANSPORTATION SOURCES

Receptor Number	Plane of Window Receptor Location	Roadway Noise Level (dBA)	
		Day	Night
1	1st Floor North Façade	59	52
2	1st Floor South Façade	58	51
3	1st Floor West Façade	62	55
4	Future Portable Units North Façade	47	40
5	Preschool Play Area	58	50
6	Infant Play Area	51	44

The results of the current analysis indicate that combined noise levels will range between 47 and 62 dBA during the daytime period (07:00-23:00) and between 40 and 55 dBA during the nighttime period (23:00-07:00). The highest noise levels (i.e. 62 dBA) occurs along the development's west façade, which is nearest and most exposed to Ralph Hennessy Avenue. Noise levels fall below the ENCG criteria for upgraded building components, however the development will require force-air heating with provision for air conditioning. Air conditioning will allow windows to remain closed while maintaining a comfortable indoor environment.

5.2 Stationary Noise Levels

As Table 8 (below) summarizes, noise levels fall below ENCG criteria during all hours of the day. Noise contours at 1.5 m above grade can be seen in Figure 8 and 9 for daytime/evening and nighttime conditions. Since the noise levels fall below ENCG criteria, the proposed development is expected to be compatible with the existing and future noise sensitive land uses.

TABLE 8: NOISE LEVELS FROM STATIONARY SOURCES

Receptor Number	Receptor Location	1-HR L_{EQ} (dBA)		ENCG Criteria (dBA)		Meets ENCG
		Daytime/ Evening	Night	Daytime/ Evening	Night	
R1	POW – Lot 51	43	40	50	45	Yes
R2	OPOR – Lot 51	40	37	45	N/A	Yes
R3	POW – Lot 272	43	40	50	45	Yes
R4	POW – Lot 212	45	42	50	45	Yes
R5	OPOR – Lot 212	42	39	45	N/A	Yes
R6	POW – Lot 174	40	37	50	45	Yes
R7	OPOR – Lot 174	42	39	45	N/A	Yes
R8	POW – Lot 149	42	39	50	45	Yes
R9	POW – Lot 146	44	41	50	45	Yes
R10	POW – Lot 143	43	40	50	45	Yes

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the current analysis indicate that combined noise levels will range between 47 and 62 dBA during the daytime period (07:00-23:00) and between 40 and 55 dBA during the nighttime period (23:00-07:00). The highest noise levels (i.e. 62 dBA) occurs along the development's west façade, which is nearest and most exposed to Ralph Hennessy Avenue. Noise levels fall below the ENCG criteria for upgraded building components, however the development will require force-air heating with provision for air conditioning. Air conditioning will allow windows to remain closed while maintaining a comfortable indoor environment.

Stationary noise levels fall below ENCG criteria during all hours of the day. Since the noise levels fall below ENCG criteria, the proposed development is expected to be compatible with the existing and future noise sensitive land uses. A review of final equipment selection and locations by a qualified acoustical engineer will be required prior to installation of the equipment.

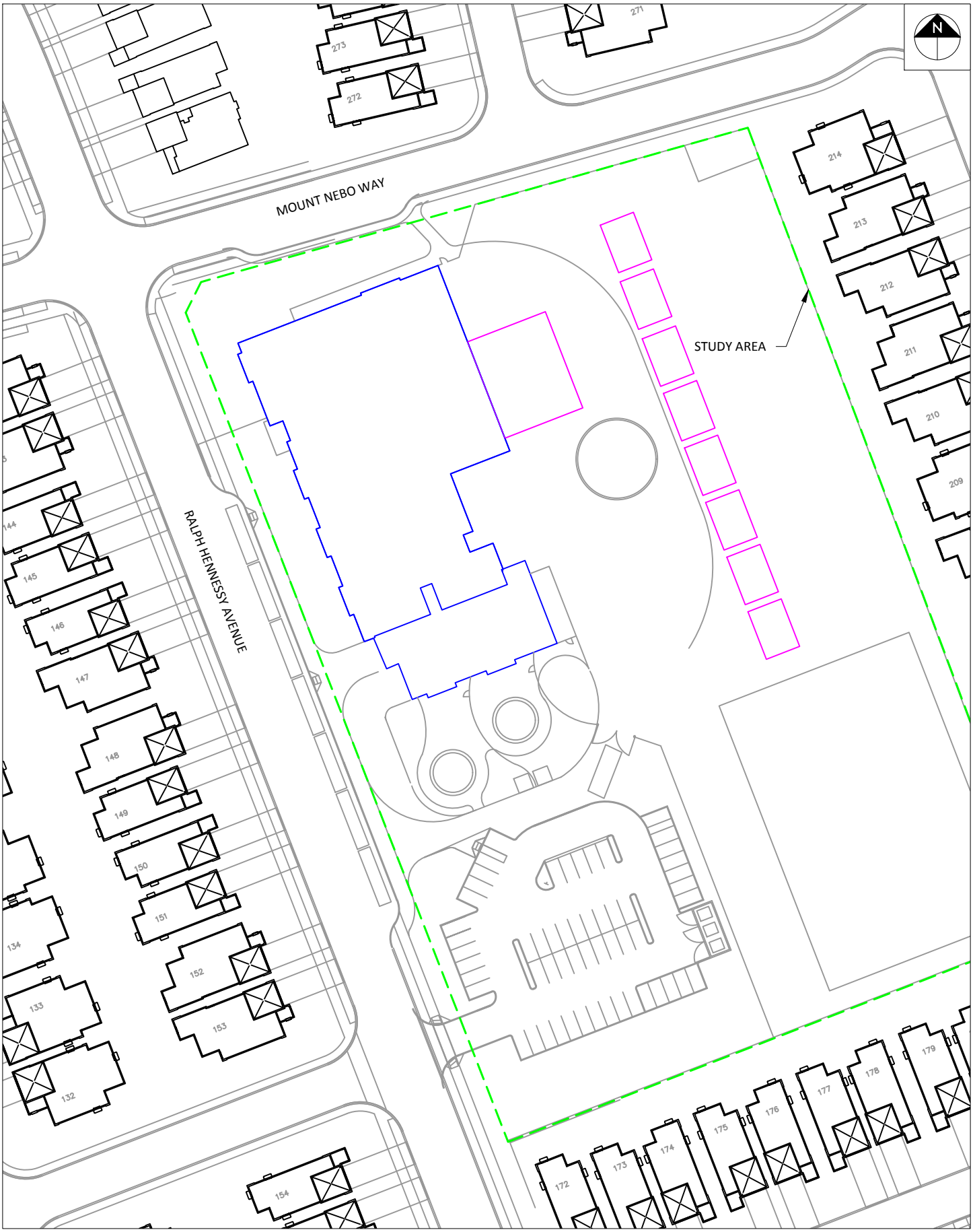
This concludes our assessment and report. If you have any questions or wish to discuss our findings please advise us. In the interim, we thank you for the opportunity to be of service.

Yours truly,

Gradient Wind Engineering Inc.

Michael Lafortune
Environmental Scientist
GWE18-094 – Environmental Noise

Joshua Foster, P.Eng.
Principal



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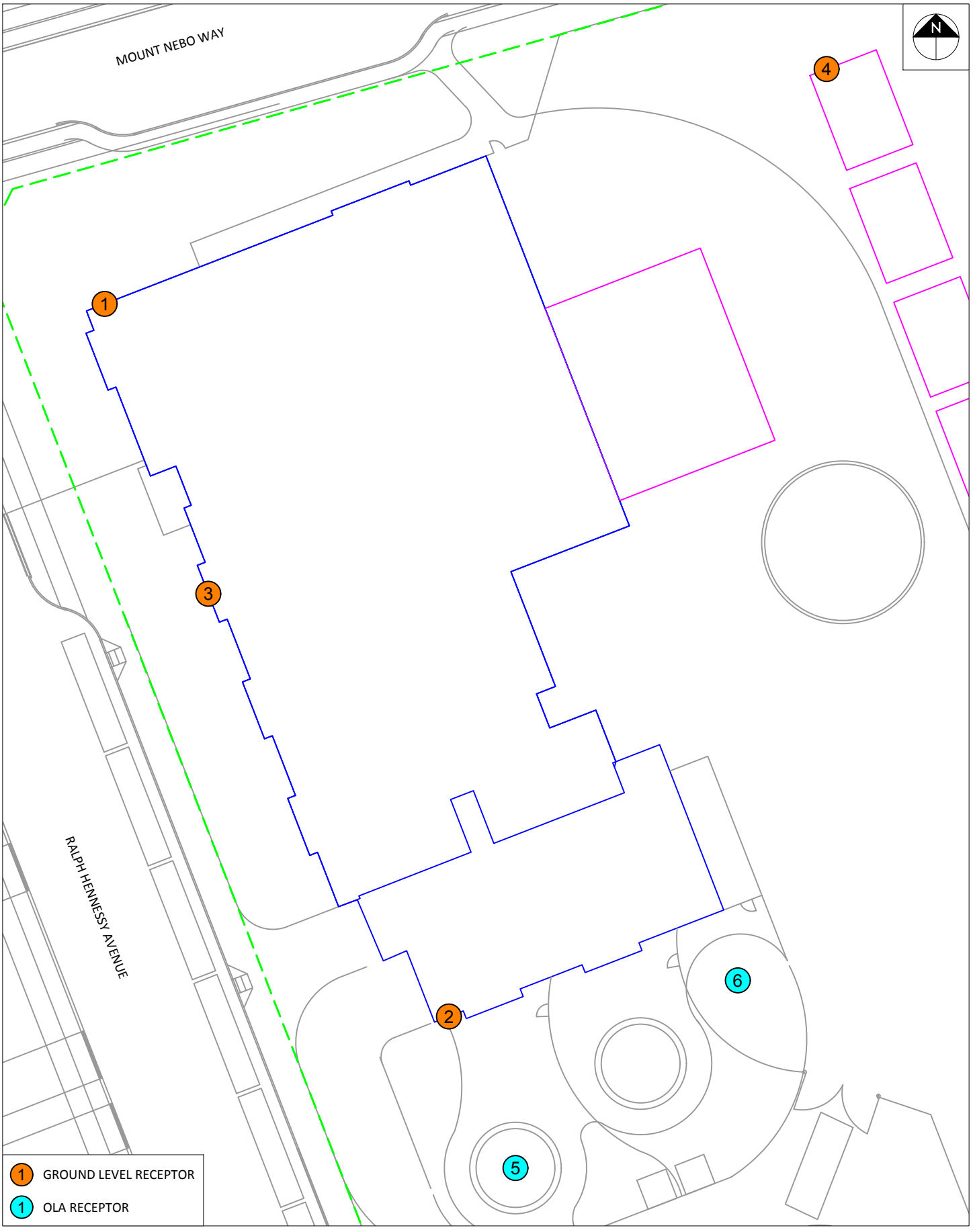
GRADIENT WIND ENGINEERING INC

PROJECT	RIVERSIDE SOUTH ELEMENTARY SCHOOL ENVIRONMENTAL NOISE ASSESSMENT
SCALE	1:1000 (APPROX.)
DRAWING NO.	GWE18-094-1
DATE	JULY 9, 2018
DRAWN BY	M.L.

DESCRIPTION

FIGURE 1:
SITE PLAN AND SURROUNDING CONTEXT



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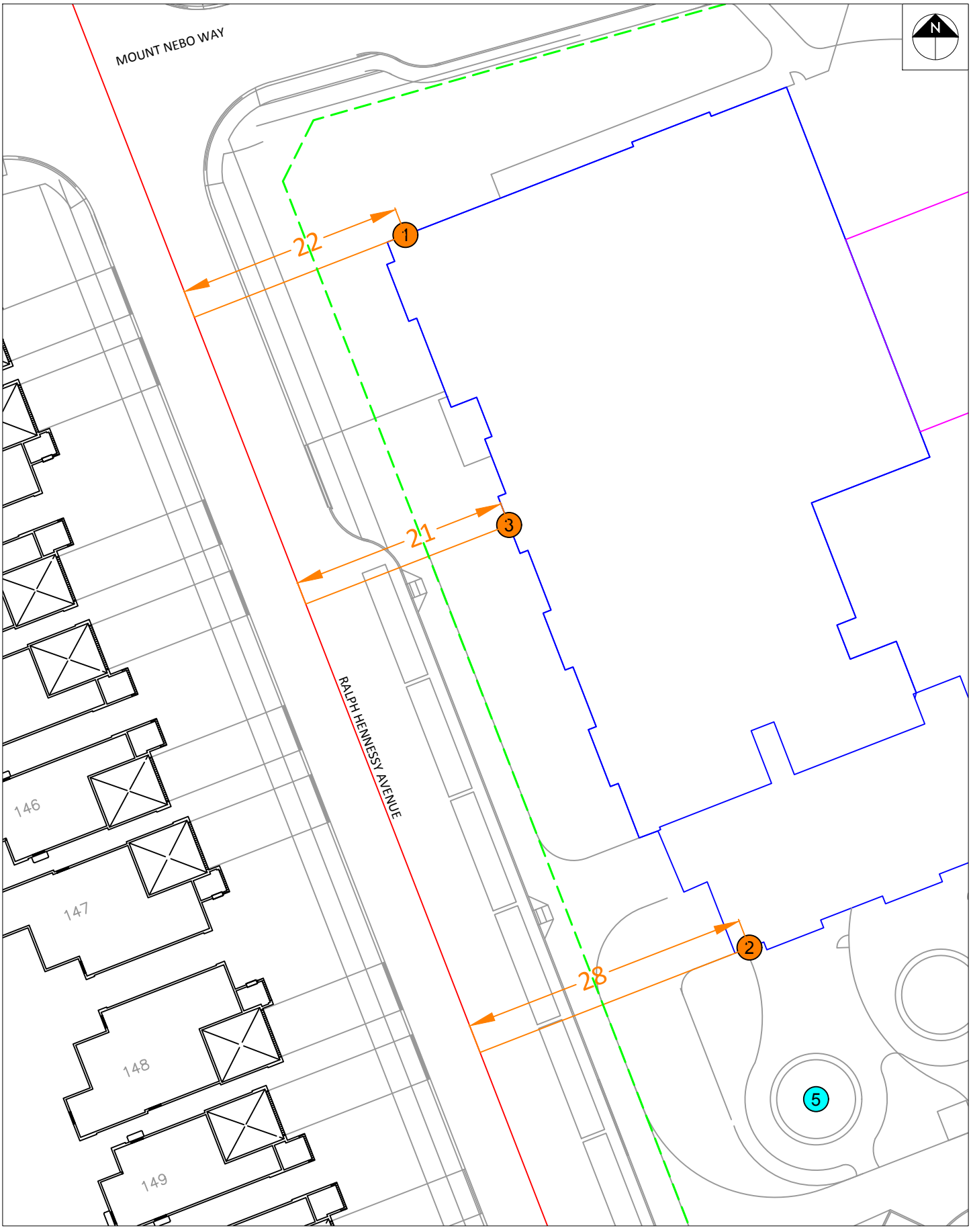
SCALE	1:500 (APPROX.)
DRAWING NO.	GWE18-094-2
DATE	JULY 9, 2018
DRAWN BY	M.L.

DESCRIPTION

FIGURE 2:
ROADWAY TRAFFIC NOISE RECEPTOR LOCATIONS



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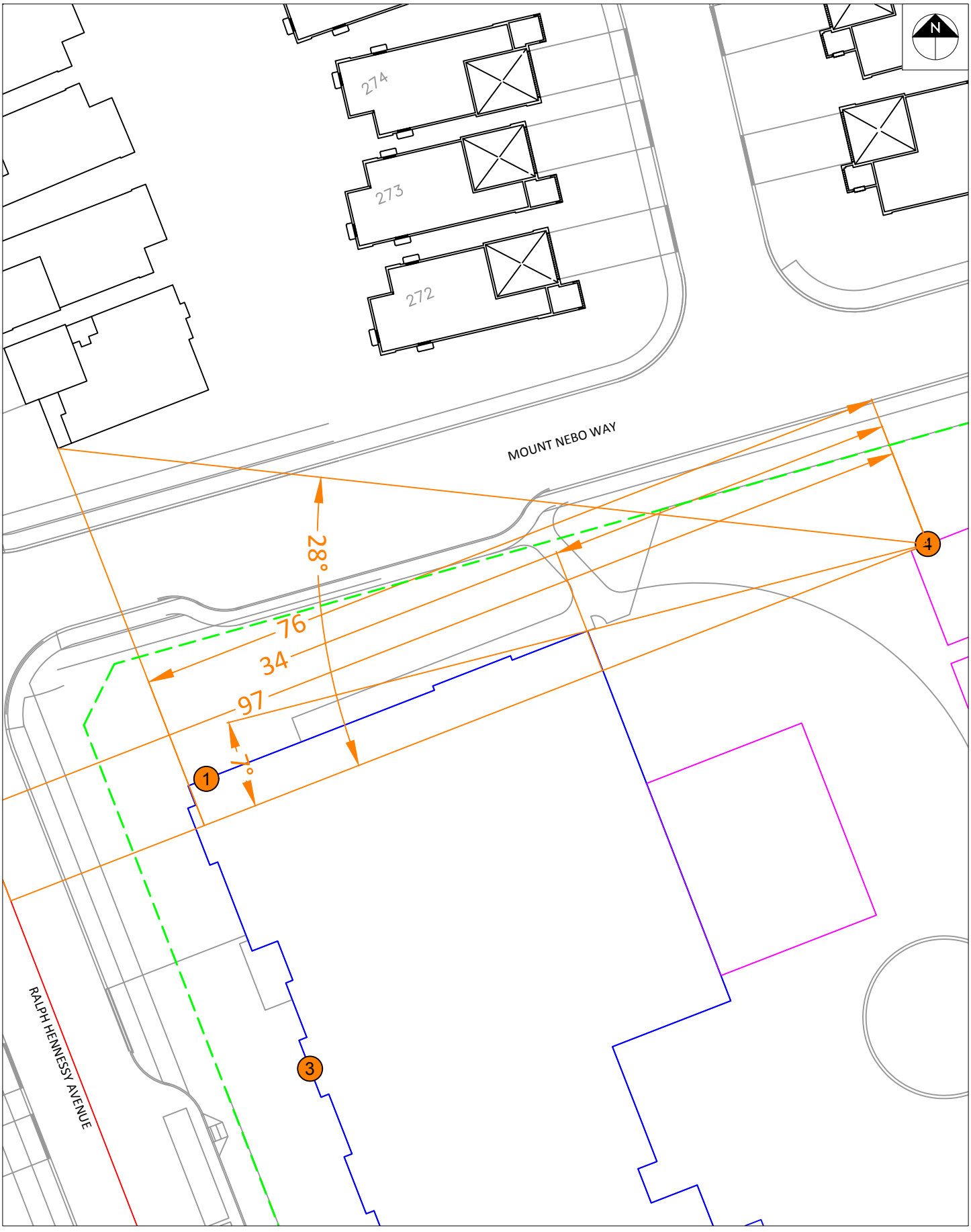
DRAWING NO.	GWE18-094-3
DATE	JULY 9, 2018
DRAWN BY	M.L.

DESCRIPTION

FIGURE 3:
STAMSON INPUT PARAMETERS - RECEPTOR 1-3



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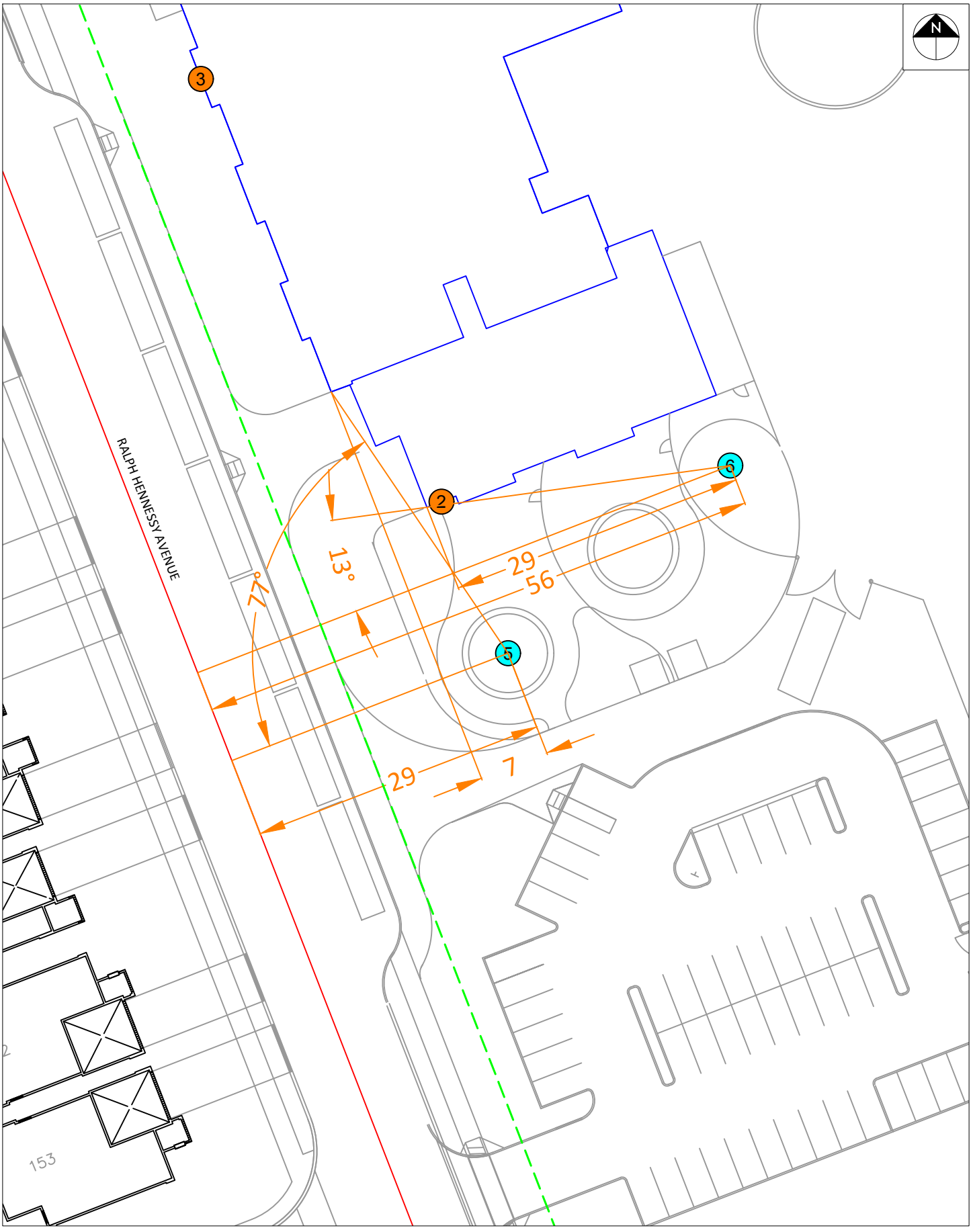
DRAWING NO.	GWE18-094-4
DATE	JULY 9, 2018
DRAWN BY	M.L.

DESCRIPTION

FIGURE 4:
STAMSON INPUT PARAMETERS - RECEPTOR 4



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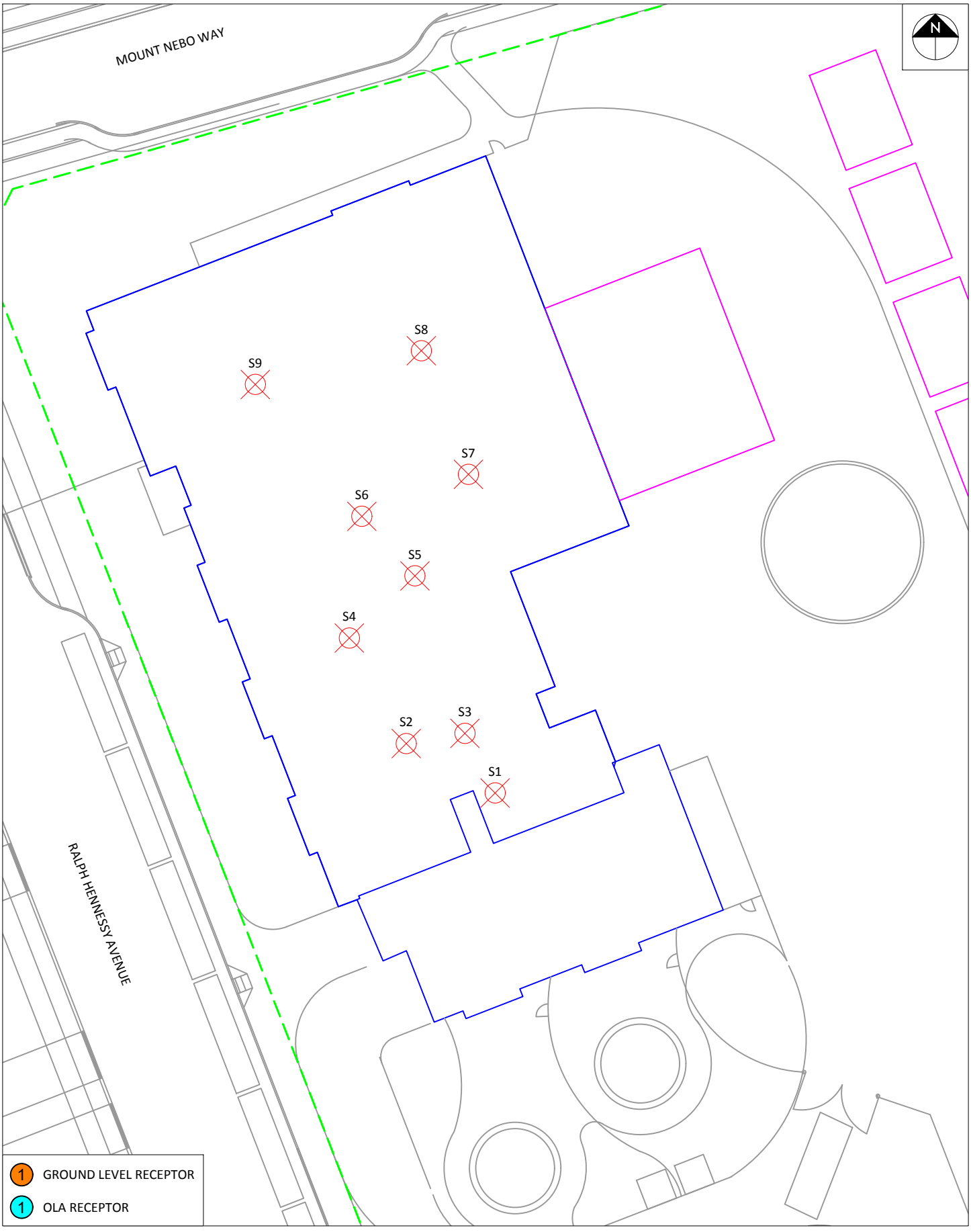
GRADIENT WIND ENGINEERING INC	SCALE: 1:500 (APPROX.)	DRAWING NO.: GWE18-094-5	FIGURE 5: STAMSON INPUT PARAMETERS - RECEPTOR 5-6
	DATE: JULY 9, 2018	DRAWN BY: M.L.	



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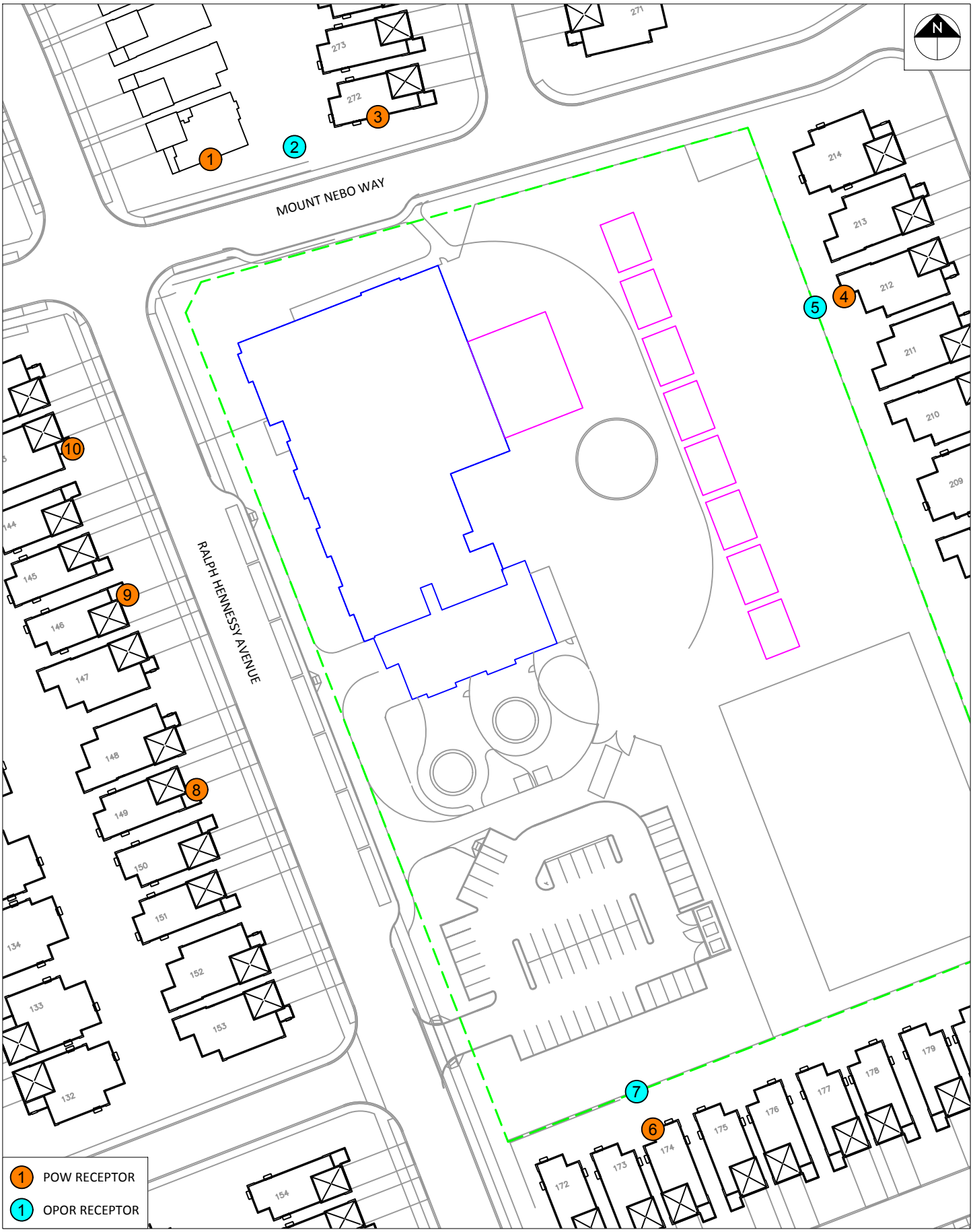
DESCRIPTION

FIGURE 6:
STATIONARY NOISE SOURCE LOCATIONS



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DRAWING NO.	GWE18-094-7
DATE	JULY 9, 2018
DRAWN BY	M.L.

DESCRIPTION

FIGURE 7:
STATIONARY NOISE RECEPTOR LOCATIONS

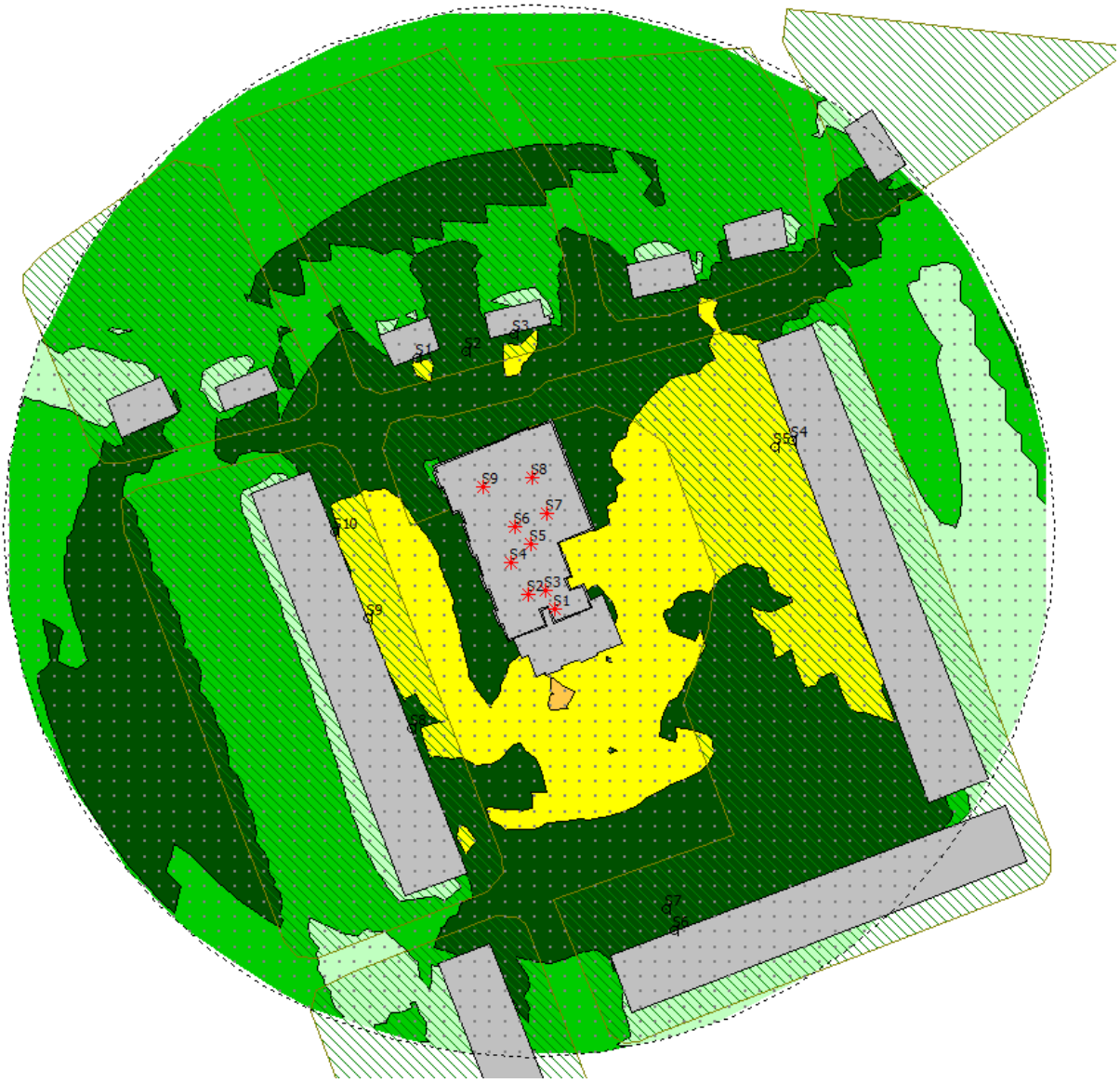

FIGURE 8: DAYTIME/EVENING STATIOANRY NOISE CONTOURS (1.5 METERS ABOVE GRADE)

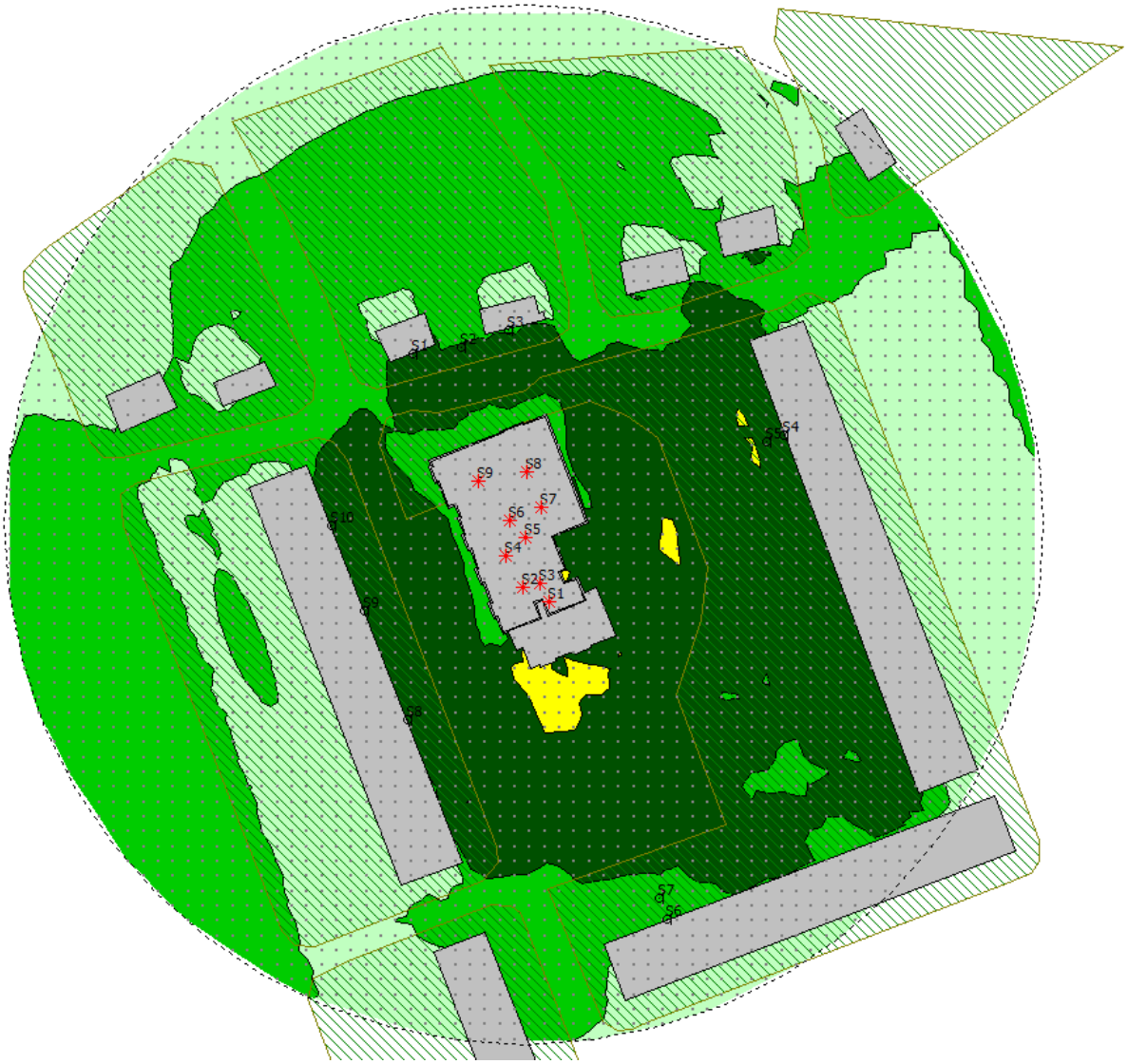

FIGURE 9: NIGHTTIME STATIONARY NOISE CONTOURS (1.5 METERS ABOVE GRADE)

80 – 85 dB
75 – 80 dB
70 – 75 dB
65 – 70 dB
60 – 65 dB
55 – 60 dB
50 – 55 dB
45 – 50 dB
40 – 45 dB
35 – 40 dB
0 – 35 dB

APPENDIX A

STAMSON 5.04 - INPUT AND OUTPUT DATA

STAMSON 5.0 NORMAL REPORT Date: 09-07-2018 11:56:02
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r1.te Time Period: Day/Night 16/8 hours
Description:

Road data, segment # 1: Ralph (day/night)

Car traffic volume	:	6477/563	veh/TimePeriod *
Medium truck volume	:	515/45	veh/TimePeriod *
Heavy truck volume	:	368/32	veh/TimePeriod *
Posted speed limit	:	40 km/h	
Road gradient	:	0 %	
Road pavement	:	1 (Typical asphalt or concrete)	

* Refers to calculated road volumes based on the following input:

24 hr Traffic Volume (AADT or SADT)	:	8000
Percentage of Annual Growth	:	0.00
Number of Years of Growth	:	0.00
Medium Truck % of Total Volume	:	7.00
Heavy Truck % of Total Volume	:	5.00
Day (16 hrs) % of Total Volume	:	92.00

Data for Segment # 1: Ralph (day/night)

Angle1 Angle2	:	0.00 deg	90.00 deg
Wood depth	:	0	(No woods.)
No of house rows	:	0 / 0	
Surface	:	2	(Reflective ground surface)
Receiver source distance	:	22.00 / 22.00	m
Receiver height	:	1.50 / 1.50	m
Topography	:	1	(Flat/gentle slope; no barrier)
Reference angle	:	0.00	

```
Results segment # 1: Ralph (day)
--------------------------------

Source height = 1.50 m

ROAD (0.00 + 59.28 + 0.00) = 59.28 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------
--
     0     90   0.00  63.96   0.00  -1.66  -3.01   0.00   0.00   0.00
59.28
-------------------------------------------------------------------------
--

Segment Leq : 59.28 dBA

Total Leq All Segments: 59.28 dBA
```

```
Results segment # 1: Ralph (night)
----------------------------------

Source height = 1.50 m

ROAD (0.00 + 51.69 + 0.00) = 51.69 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------
--
     0     90   0.00  56.36   0.00  -1.66  -3.01   0.00   0.00   0.00
51.69
-------------------------------------------------------------------------
--

Segment Leq : 51.69 dBA

Total Leq All Segments: 51.69 dBA
```

```
TOTAL Leq FROM ALL SOURCES (DAY): 59.28
                           (NIGHT): 51.69
```

```
STAMSON 5.0        NORMAL REPORT        Date: 09-07-2018 11:56:07
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r2.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Ralph (day/night)
----------------------------------------
Car traffic volume  :  6477/563   veh/TimePeriod  *
Medium truck volume :   515/45    veh/TimePeriod  *
Heavy truck volume  :   368/32    veh/TimePeriod  *
Posted speed limit  :    40 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):   8000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Ralph (day/night)
---------------------------------------
Angle1   Angle2           : -90.00 deg   0.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  28.00 / 28.00  m
Receiver height           :   1.50 / 1.50   m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

```
Results segment # 1: Ralph (day)
---------------------------------

Source height = 1.50 m

ROAD (0.00 + 58.23 + 0.00) = 58.23 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------
--
   -90      0   0.00  63.96   0.00  -2.71  -3.01   0.00   0.00   0.00
58.23
-------------------------------------------------------------------------
--

Segment Leq : 58.23 dBA

Total Leq All Segments: 58.23 dBA
```

```
Results segment # 1: Ralph (night)
----------------------------------

Source height = 1.50 m

ROAD (0.00 + 50.64 + 0.00) = 50.64 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------
--
   -90      0   0.00  56.36   0.00  -2.71  -3.01   0.00   0.00   0.00
50.64
-------------------------------------------------------------------------
--

Segment Leq : 50.64 dBA

Total Leq All Segments: 50.64 dBA
```

```
TOTAL Leq FROM ALL SOURCES (DAY): 58.23
                           (NIGHT): 50.64
```

```
STAMSON 5.0        NORMAL REPORT        Date: 09-07-2018 11:56:11
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r3.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Ralph (day/night)
----------------------------------------
Car traffic volume  :  6477/563   veh/TimePeriod  *
Medium truck volume :   515/45    veh/TimePeriod  *
Heavy truck volume  :   368/32    veh/TimePeriod  *
Posted speed limit  :    40 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):   8000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Ralph (day/night)
---------------------------------------
Angle1   Angle2           : -90.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  21.00 / 21.00  m
Receiver height           :   1.50 / 1.50   m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

```
Results segment # 1: Ralph (day)
--------------------------------

Source height = 1.50 m

ROAD (0.00 + 62.49 + 0.00) = 62.49 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------
--
   -90     90   0.00  63.96   0.00  -1.46   0.00   0.00   0.00   0.00
62.49
-------------------------------------------------------------------------
--

Segment Leq : 62.49 dBA

Total Leq All Segments: 62.49 dBA
```

```
Results segment # 1: Ralph (night)
----------------------------------

Source height = 1.50 m

ROAD (0.00 + 54.90 + 0.00) = 54.90 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------
--
   -90     90   0.00  56.36   0.00  -1.46   0.00   0.00   0.00   0.00
54.90
-------------------------------------------------------------------------
--

Segment Leq : 54.90 dBA

Total Leq All Segments: 54.90 dBA
```

```
TOTAL Leq FROM ALL SOURCES (DAY): 62.49
                           (NIGHT): 54.90
```

```
STAMSON 5.0        NORMAL REPORT        Date: 09-07-2018 11:56:16
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r4.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Ralph1 (day/night)
----------------------------------------
Car traffic volume  :  6477/563   veh/TimePeriod  *
Medium truck volume :   515/45    veh/TimePeriod  *
Heavy truck volume  :   368/32    veh/TimePeriod  *
Posted speed limit  :    40 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):   8000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Ralph1 (day/night)
----------------------------------------
Angle1   Angle2           :   0.00 deg   28.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  97.00 / 97.00  m
Receiver height           :   1.50 / 1.50   m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            :   0.00 deg   Angle2 : 7.00 deg
Barrier height            :   8.00 m
Barrier receiver distance :  34.00 / 34.00  m
Source elevation          :   0.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00
```

```
Road data, segment # 2: Ralph2 (day/night)
------------------------------------------
Car traffic volume  :  6477/563   veh/TimePeriod  *
Medium truck volume :   515/45    veh/TimePeriod  *
Heavy truck volume  :   368/32    veh/TimePeriod  *
Posted speed limit  :    40 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):   8000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 2: Ralph2 (day/night)
----------------------------------------
Angle1   Angle2           :  28.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  97.00 / 97.00  m
Receiver height           :   1.50 / 1.50   m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            :  28.00 deg   Angle2 : 90.00 deg
Barrier height            :   6.00 m
Barrier receiver distance :  76.00 / 76.00  m
Source elevation          :   0.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00
```

```
Results segment # 1: Ralph1 (day)
---------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !        1.50 !        1.50 !         1.50

ROAD (0.00 + 24.35 + 46.52) = 46.54 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------------
--
     0      7   0.00  63.96   0.00  -8.11 -14.10   0.00   0.00 -17.40
24.35
-------------------------------------------------------------------------------
--
     7     28   0.00  63.96   0.00  -8.11  -9.33   0.00   0.00   0.00
46.52
-------------------------------------------------------------------------------
--

Segment Leq : 46.54 dBA
```

```
Results segment # 2: Ralph2 (day)
---------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !        1.50 !        1.50 !         1.50

ROAD (0.00 + 40.17 + 0.00) = 40.17 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------------
--
    28     90   0.00  63.96   0.00  -8.11  -4.63   0.00   0.00 -11.05
40.17
-------------------------------------------------------------------------------
--

Segment Leq : 40.17 dBA

Total Leq All Segments: 47.44 dBA
```

```
Results segment # 1: Ralph1 (night)
-----------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !        1.50 !        1.50 !         1.50

ROAD (0.00 + 16.75 + 38.92) = 38.95 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------------
--
     0      7   0.00  56.36   0.00  -8.11 -14.10   0.00   0.00 -17.40
16.75
-------------------------------------------------------------------------------
--
     7     28   0.00  56.36   0.00  -8.11  -9.33   0.00   0.00   0.00
38.92
-------------------------------------------------------------------------------
--

Segment Leq : 38.95 dBA
```

```
Results segment # 2: Ralph2 (night)
-----------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !        1.50 !        1.50 !         1.50

ROAD (0.00 + 32.58 + 0.00) = 32.58 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------------
--
    28     90   0.00  56.36   0.00  -8.11  -4.63   0.00   0.00 -11.05
32.58
-------------------------------------------------------------------------------
--

Segment Leq : 32.58 dBA

Total Leq All Segments: 39.85 dBA
```

```
TOTAL Leq FROM ALL SOURCES (DAY): 47.44
                           (NIGHT): 39.85
```

```
STAMSON 5.0        NORMAL REPORT        Date: 09-07-2018 11:56:20
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r5.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Ralph (day/night)
----------------------------------------
Car traffic volume  :  6477/563   veh/TimePeriod  *
Medium truck volume :   515/45    veh/TimePeriod  *
Heavy truck volume  :   368/32    veh/TimePeriod  *
Posted speed limit  :    40 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):   8000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Ralph (day/night)
---------------------------------------
Angle1   Angle2           : -90.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  :  29.00 / 29.00  m
Receiver height           :   1.50 / 1.50   m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            :  77.00 deg   Angle2 : 90.00 deg
Barrier height            :   8.00 m
Barrier receiver distance :   7.00 / 7.00   m
Source elevation          :   0.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00
```

```
Results segment # 1: Ralph (day)
---------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !        1.50 !        1.50 !         1.50

ROAD (57.65 + 35.57 + 0.00) = 57.67 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------------
--
   -90     77   0.66  63.96   0.00  -4.75  -1.56   0.00   0.00   0.00
57.65
-------------------------------------------------------------------------------
--
    77     90   0.18  63.96   0.00  -3.38 -13.29   0.00   0.00 -11.71
35.57
-------------------------------------------------------------------------------
--

Segment Leq : 57.67 dBA

Total Leq All Segments: 57.67 dBA
```

```
Results segment # 1: Ralph (night)
----------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !        1.50 !        1.50 !         1.50

ROAD (50.05 + 27.98 + 0.00) = 50.08 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------------
--
   -90     77   0.66  56.36   0.00  -4.75  -1.56   0.00   0.00   0.00
50.05
-------------------------------------------------------------------------------
--
    77     90   0.18  56.36   0.00  -3.38 -13.29   0.00   0.00 -11.71
27.98
-------------------------------------------------------------------------------
--

Segment Leq : 50.08 dBA

Total Leq All Segments: 50.08 dBA
```

```
TOTAL Leq FROM ALL SOURCES (DAY): 57.67
                           (NIGHT): 50.08
```

```
STAMSON 5.0        NORMAL REPORT        Date: 09-07-2018 11:56:25
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r6.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Ralph (day/night)
----------------------------------------
Car traffic volume  :  6477/563   veh/TimePeriod  *
Medium truck volume :   515/45    veh/TimePeriod  *
Heavy truck volume  :   368/32    veh/TimePeriod  *
Posted speed limit  :    40 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):   8000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Ralph (day/night)
---------------------------------------
Angle1   Angle2           : -90.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  :  56.00 / 56.00  m
Receiver height           :   1.50 / 1.50   m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            :  13.00 deg   Angle2 : 90.00 deg
Barrier height            :   4.00 m
Barrier receiver distance :  29.00 / 29.00  m
Source elevation          :   0.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00
```

```
Results segment # 1: Ralph (day)
---------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !        1.50 !        1.50 !         1.50

ROAD (50.79 + 42.05 + 0.00) = 51.33 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------------
--
   -90     13   0.66  63.96   0.00  -9.50  -3.67   0.00   0.00   0.00
50.79
-------------------------------------------------------------------------------
--
    13     90   0.42  63.96   0.00  -8.12  -4.91   0.00   0.00  -8.87
42.05
-------------------------------------------------------------------------------
--

Segment Leq : 51.33 dBA

Total Leq All Segments: 51.33 dBA
```

```
Results segment # 1: Ralph (night)
----------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !        1.50 !        1.50 !         1.50

ROAD (43.19 + 34.46 + 0.00) = 43.74 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------------
--
   -90     13   0.66  56.36   0.00  -9.50  -3.67   0.00   0.00   0.00
43.19
-------------------------------------------------------------------------------
--
    13     90   0.42  56.36   0.00  -8.12  -4.91   0.00   0.00  -8.87
34.46
-------------------------------------------------------------------------------
--

Segment Leq : 43.74 dBA

Total Leq All Segments: 43.74 dBA
```

```
TOTAL Leq FROM ALL SOURCES (DAY): 51.33
                           (NIGHT): 43.74
```

APPENDIX B

PREDICTOR LIMA - OUTPUT DATA

Testfile openend: ######## 10:28:08 AM

Cross section for receiver S6 (Id=-73) and source S1 (Id=78)

ItemType	Id	Distance	X	Y	Hgrnd	Height	GrndFact	Cluster
Receiver	S6	0	426.34	340.51	0	4.5	1	
Ground	LWPOLYLIN	23.36	418.17	362.39	0	0	0	
Building	LWPOLYLIN	95.406	392.97	429.89	0	4	0	1
Building	LWPOLYLIN	109.706	387.97	443.29	0	7.6	0	1
Barrier	LWPOLYLIN	110.206	387.8	443.76	7.6	0.7	0	1
Pointsourc	S1	114.271	386.38	447.57	7.6	1.5	0	

L(wr)	66	66	71	74	79	78	75	72	69
A(ground)	-3	-3	-2.15	-2.44	-2.69	-2.69	-2.69	-2.69	-2.69
A(barrier)	0	0	0	0	0	0	0	0	0
A(veg)	0	0	0	0	0	0	0	0	0
A(sit)	0	0	0	0	0	0	0	0	0
A(bld)	0	0	0	0	0	0	0	0	0
A(air)	0	0.01	0.05	0.12	0.22	0.42	1.11	3.75	13.37
A(geo)	52.16	52.16	52.16	52.16	52.16	52.16	52.16	52.16	52.16
C(meteo)	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
L(p)	15.89	15.88	20	23.21	28.36	27.17	23.48	17.84	5.22

L(p)	32.74

Cross section for receiver S6 (Id=-73) and source S1 (Id=78)
[Reflection in facade LWPOLYLIN (Id=97)]

ItemType	Id	Distance	X	Y	Hgrnd	Height	GrndFact	Cluster
Receiver	S6	0	426.34	340.51	0	4.5	1	
Ground	LWPOLYLIN	23.362	418.02	362.34	0	0	0	
Building	LWPOLYLIN	95.4	392.38	429.66	0	4	0	1
Building	LWPOLYLIN	109.699	387.29	443.02	0	7.6	0	1
Barrier	LWPOLYLIN	110.199	387.11	443.49	7.6	0.7	0	1
Ground	LWPOLYLIN	168.055	366.52	497.56	0	0	1	
Barrier(R)	LWPOLYLIN	172.587	364.9	501.79	7.6	0.7	1	
Ground	LWPOLYLIN	177.087	366.56	497.61	0	0	0	
Pointsourc	S1	230.911	386.38	447.57	7.6	1.5	0	

L(wr)	66	66	71	74	79	78	75	72	69
A(ground)	-3.66	-3.66	-2.76	-3.05	-3.28	-3.28	-3.28	-3.28	-3.28
A(barrier)	8.43	8.43	7.54	7.83	8.07	8.09	8.12	8.18	8.29
A(veg)	0	0	0	0	0	0	0	0	0
A(sit)	0	0	0	0	0	0	0	0	0
A(bld)	0	0	0	0	0	0	0	0	0
A(air)	0.01	0.03	0.09	0.24	0.45	0.84	2.23	7.57	26.99
A(geo)	58.26	58.26	58.26	58.26	58.26	58.26	58.26	58.26	58.26
A(refl)	--	--	--	--	--	--	--	--	--
C(meteo)	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
L(p)	--	--	--	--	--	--	--	--	--

L(p)	-200

Height	Source	Per	LAeq	32	63	125	250	500	1000	2000	4000	8000
4.5	S1	1	32.74	15.89	15.88	20	23.21	28.36	27.17	23.48	17.84	5.22
4.5	S1	2	--	--	--	--	--	--	--	--	--	--
4.5	S1	3	29.73	12.88	12.87	16.99	20.2	25.35	24.16	20.47	14.83	2.21
4.5	S1	4	--	--	--	--	--	--	--	--	--	--

Height	Per	LAeq	32	63	125	250	500	1000	2000	4000	8000
4.5	1	32.74	15.89	15.88	20	23.21	28.36	27.17	23.48	17.84	5.22
4.5	2	--	--	--	--	--	--	--	--	--	
4.5	3	29.73	12.88	12.87	16.99	20.2	25.35	24.16	20.47	14.83	2.21
4.5	4	--	--	--	--	--	--	--	--	--	

0.0001; 154; 0.0000008; TTimerSet - overhead
0.0006; 77; 0.0000072; WriteTestString

==========

Testfile closed: ######## 10:28:08 AM

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